

**A RADIATION SENSITIVE RECORDING PLATE AND METHOD OF MAKING
AND USING SAME**

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application Serial No. 60/372,323, entitled "METHOD FOR INTERNALLY LABELING THE ORIENTATION OF EXPOSURE OF RADIATION-SENSITIVE PLATES BY PRODUCING A RECOGNIZABLE PATTERN WITHIN THE INFORMATION SET PRODUCED BY SUCH EXPOSURE," filed on April 12, 2002, and to U.S. Provisional Patent Application Serial No. 60/431,282, entitled "A RADIATION SENSITIVE RECORDING PLATE, A METHOD OF MAKING SAME AND A METHOD OF RECORDING AND ORIENTING IMAGES," filed on December 6, 2002, and to U.S. Patent Application Serial No. 10/392,158, entitled "A RADIATION SENSITIVE RECORDING PLATE AND METHOD OF MAKING AND USING SAME," filed on March 18, 2003, all of which are herein incorporated by reference in their entirety.

BACKGROUND

This application relates generally to image processing. More specifically, the application relates to identifying image orientation. Yet more specifically, the application relates to identifying image orientation in medical and dental X-ray shadow-grams.

Images produced in conventional roll-film cameras, on film, are easy to orient correctly because the camera is constructed in such a way that the emulsion of the film always faces the lens. Because of the shapes of film cassettes and cameras, the film cannot be inserted in modern cameras with the emulsion facing away from the lens, so it is always known that the light, or other radiation recorded by the film, struck the film from the emulsion side. Thus, when orienting slides for projection, or film images for viewing on a light box, it is always known to put the emulsion toward the projection lens in the slide projector, or to put the film on the light box with the emulsion towards the viewer. When that is done, the image seen by the viewer, whether projected or viewed on the light box, will have a known defined correspondence with the orientation of the objects in the original scene. Moreover, even if orientation is lost, reorienting based on determining where the emulsion is will reestablish proper orientation.

Likewise, digital images produced using cameras with detectors such as charge-coupled devices (CCDs) that are sensitive to exposure from one side only are inherently unambiguous.

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from FIG. 38 that for both the "portrait" and for the "landscape" orientation a combination of rotation within the plane and reflection through a perpendicular plane manipulation, as described earlier, is sufficient to generate all the possible locations of the marker. It is also evident that all paths involving odd number of reflections (i.e. one which generates a net shift of the image to a different row in FIG. 38) are qualitatively different from the paths involving an even number of reflections (i.e. no net shift of row generated in the process). Therefore, assuming an original position of the marker 3811 in the lower right corner in a "landscape" orientation as in image 3801, it is clear that relative to original image 3801, the laterality of image 3803 has not been reversed but that of image 3807 has been. Furthermore, without the knowledge of the original image 3809, 3810 it is possible to deduce its laterality by observation of the marker location and the "portrait" vs. "landscape" orientation of the plate. It should also be noted that teeth of the lower and the upper jaw are significantly enough different to allow their recognition in radiographic images thereby preserving orientation in the superior-inferior dimension. By analogy, if the long arrow 3810 is assumed to serve as a recognizable index for the superior direction, and the short arrow 3809, the forward direction, then only images 3801 and 3805 present images properly oriented with respect to the superior-inferior dimension. Furthermore, of those two, only image 3801 has preserved the original laterality of the object casting the shadow. Further complicating the situation is that the plate could have been exposed from the "back side" and viewed from the "front side", resulting in image 3805. This image must be reflected horizontally to be viewed in the "correct" orientation of image 3801.

Suppose, for the purpose of analyzing the images in FIGS. 2, 3, 4 and 5, that the technician, dentist or other exposing this patient's digital dental X-ray plate 104 has oriented the "front side" defined above, carrying the open circle, and consequently the sensitive side of the plate 104, toward the X-ray source located at the position SORCU L, and in the lower right corner of the plate 104 as viewed from the direction of the X-ray source located at the position SOURCE L. FIG. 3 is the image read from the "front side of the plate 104, when the plate so oriented is exposed by an X-ray at the location designated SOURCE R. If the dentist reading such an image is aware that the exposure has been made from the "wrong" side, i.e., the "back side", of the

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plate, the dentist can use image processing software to reorient the image horizontally flipping the image, as shown in FIG. 2. Mark 201 is transposed from the right to the left, side of the image. The same plate 104, oriented the same way, but exposed

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FIG. 41 is a plan view of a plate showing the relative positions of dual "front side" markers (solid) and dual "back side" markers (phantom);

FIG. 42 is transform map of the plate of FIG. 41;

FIG. 43 is a cross-sectional view of an aspect of an embodiment of the invention using a rivet or brad to form both a "front side" marker and a "back side" marker;

FIGS. 44A & 44B is a plan views of a double-phosphor plate showing the relative positions of a "front side" marker (solid arrow, phantom arrow) and a "back side" marker (phantom diamond when viewed from either side, and representing exposure and viewing from the same side;

FIG. 45 is a plan view of an image produced by a double-phosphor plate showing the relative positions of the "front side" marker and the "back side" marker when exposed from one side and viewed from the other side, after the image has been flipped horizontally;

FIG. 46 is an exploded perspective view of a plate according to aspects of an embodiment of the invention including at least one frame applied to the plate;

FIG. 47 is an exploded perspective view of a plate having a transparent substrate and protective layer, so that the plate can be read from either side;

FIG. 48 is a plan view of an image produced by the plate of FIG. 47 which has been exposed from and read from the same side;

FIG. 49 is a plan view of an image produced by the plate of FIG. 47 which has been exposed from one side and read from the other side;

FIG. 50 is a plan view of a plate adapted to receive a corner marker feature;

FIG. 51 is a perspective view of the corner marker feature to be received by the plate of FIG. 50;

FIG. 52 is a bottom edge view of the plate of FIG. 50, including the corner marker feature of FIG. 51; and

FIG. 53 is a plan view of a plate having a simplified marker system according to some aspects of embodiments of the invention.

DETAILED DESCRIPTION

A detailed description of various aspects of embodiments of the invention follows. This invention is not limited in its application to the details of construction.

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and the arrangement of components set forth in the following description or illustrated in the drawings.

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reflect horizontally the image 4008, to produce image 4010. The corrected image 4010 has the thick, "back side" marker arrow at the upper edge facing left.

5 A simple rule can be derived from the four foregoing hypothetical using aspects of the third embodiment, whereby any image produced using the embodiment can be quickly and accurately oriented correctly for viewing. For the landscape mode images, after orienting an image correctly with respect to superior/inferior parts using rotation, any marker arrow at the top edge of the image should point left, any marker arrow at the bottom edge of the image should point right. The image must, using software, be reflected horizontally to achieve correct orientation if the rule is not met
10 initially.

In a fourth embodiment of the invention, illustrated in FIG. 41, two "front side" 4101, 4102 and two "back side" markers 4103, 4104 are used in the following manner. The relationship between markers 4101, 4103, and 4104 is similar to that described in connection with markers 3901 and 3902 of the third embodiment.
15 However, a second set of markers 4102, 4104 bearing a similar relationship is located at the point of reflection of the first set through a line passing perpendicularly through the center of the face of the plate.

All possible images 4201-4208 generated by scanning such a plate exposed to a radiation source from the "front side" and from the "back side" are shown in
20 corresponding positions to those of FIG. 40. The arrows associated with the properly oriented images all point to the right if they are in the lower half of the image and to the left if they are in the upper half of the image, making a rule stated above even easier to apply. Such design of the marker shape and location in the processed image facilitates not only accurate and unambiguous orientation but also further reduces the
25 number of decisions that an operator must make in the process of arranging the images in the mount, thus reducing the time required for the operation.

Furthermore, even if one of the markers should be obscured by the shadow of a clinical structure which is radiopaque, e.g. a metallic filling or crown, the other is present to even in this rare situation provide indication of the laterality of the image.

30 In a yet another embodiment of the invention, the plate is fitted with two layers of sensitive material, each possessing a small "front side" marker and allowing

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the mechanism which converts the latent image into a visible diagnostic image to read the plate from either or both sides and producing a recognizable pattern of that marker in such a diagnostic image, and a different indicator-informing marker, housed between the two sensitive layers,

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capable of producing a recognizable patter, preferably the image of the "front side" marker as in the foregoing embodiment, readable from either of the sensitive layers if such material lies between a radiation source and that layer.

An example of aspects of this embodiment is shown by the plate 4400
5 illustrated in FIGS. 44A and 44B. The "front side" marker set FIG. 44A is
compromised of two pairs, one pair on each side, of two arrows 4401, arranged on the
plate in the following manner: each arrow, lying along and near a long edge if the
plate, originates near the midpoint of the nearest long edge, originates near the
midpoint of the nearest long edge and points toward the right short edge if it is located
10 near the lower edge, or toward the left short edge if lying near the upper long edge.
The same arrangement of arrows is present on the reverse side of the plate. The two
arrows reflect onto one another through the point of intersection 4402 of the long
4403 and the short 4404 axes of symmetry of the plate as represented in FIGS. 44A
and 44 B. The resulting "front side" marker configuration is such that the two sides
15 4405 and 4406 of the plate are indistinguishable from one another through any
manipulations that preserve the "landscape" or "portrait" orientation of the plate 4400,
i.e. any 180 degree or multiple thereof, rotation about any of the principal axes 4403
and 4404 of symmetry or the point 4402 of symmetry.

According to further aspects of this embodiment, between the two phosphor
20 film layers lie near the tail ends of each of the four arrows 4401, radiopaque medium
deposits 4407 which can cast a shadow onto the phosphor on the other side of the
plate opposite the source of radiation and the radiographed object. In the landscape
orientation (as shown), the above arrangement of arrow-shaped "front side" markers
4401 and internal material 4407 compromising a "back side" marker, any image of an
25 object exposed from and read from the same side of the plate will have proper
orientation, as always, as scanned, with the lower edge arrow 4401 pointing to the
right and the "back side" marker 4407 shadow absent. On the other hand, as shown in
FIG. 45, any image 4501 of an object exposed from one side of the plate and read
from the other will reveal the back side" marker image 4502, which will appear at the
30 right side, i.e. the tail, of the lower arrow 4503 when diagnostic image has been
properly oriented by the software. An image with the lower arrow (FIG. 44, 4401)

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pointing right in the absence of the "back side" marker shadow has also been properly oriented. However, an image (not shown) with a "back side" marker shadow present at the left end, i.e. the tail, of the "front side" marker would indicate an image in which right and left are reversed and requiring software reflection for

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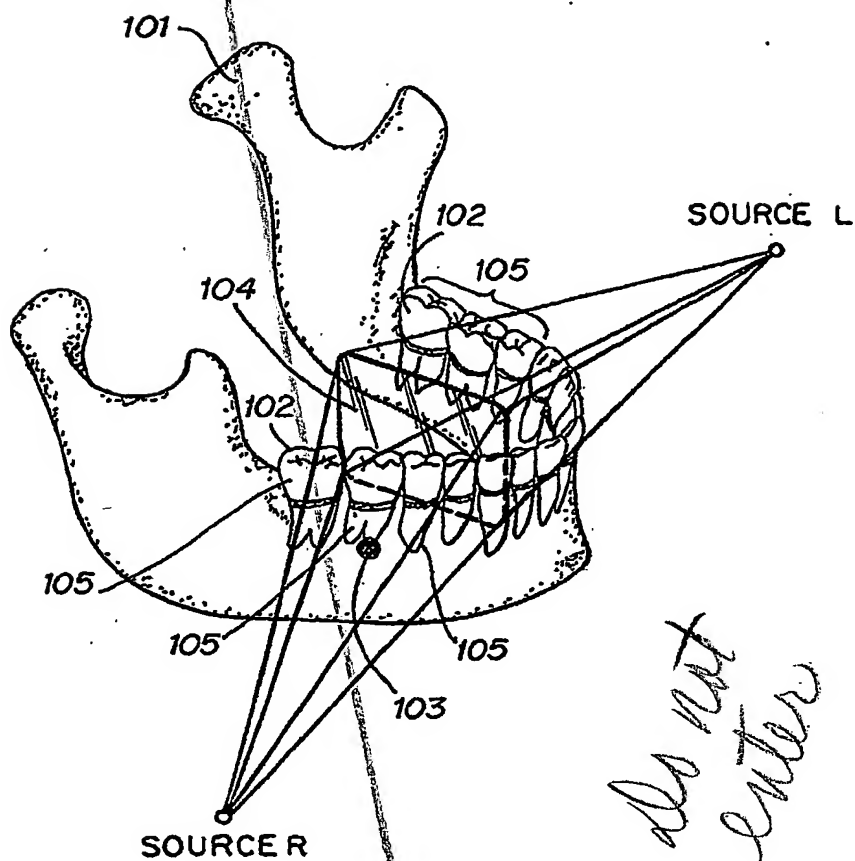


Fig. 1

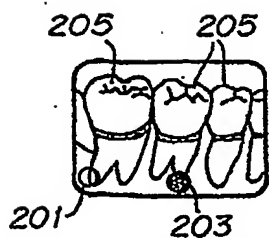


Fig. 2

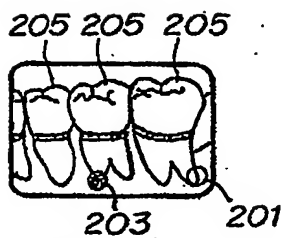


Fig. 3

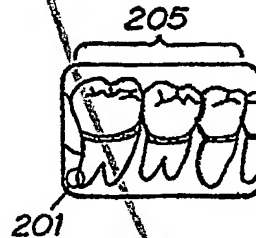


Fig. 4

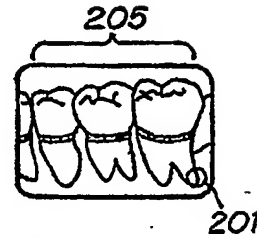


Fig. 5

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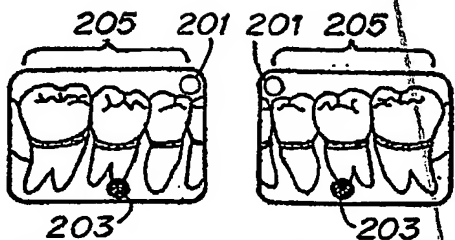


Fig. 6

Fig. 7

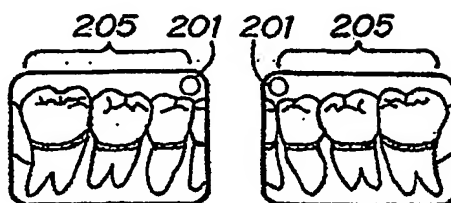


Fig. 8

Fig. 9

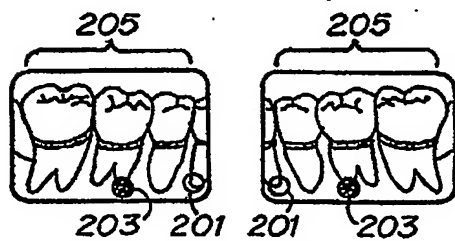


Fig. 10

Fig. 11

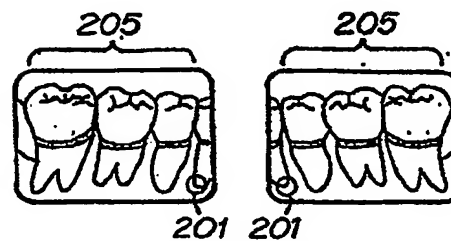


Fig. 12

Fig. 13

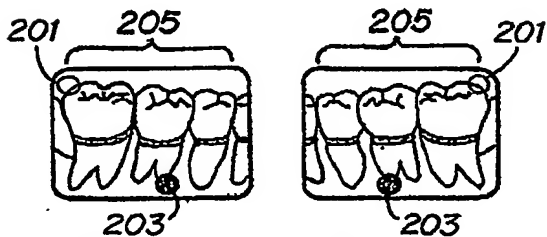


Fig. 14

Fig. 15

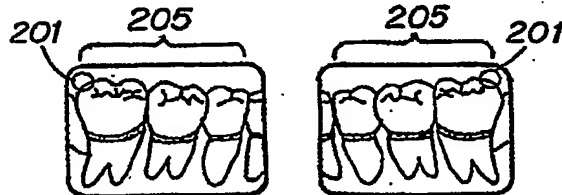


Fig. 16

Fig. 17

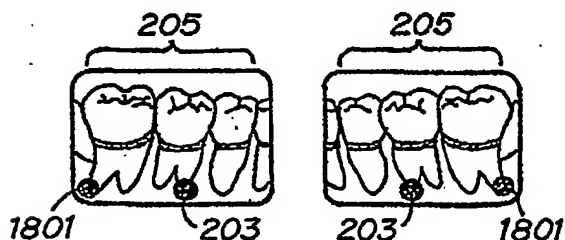


Fig. 18

Fig. 19

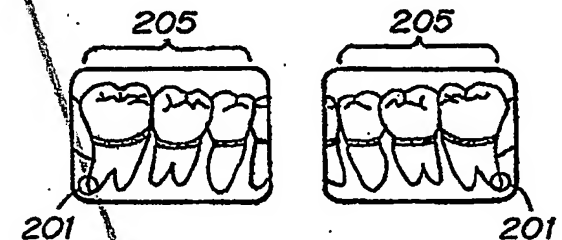


Fig. 21

Fig. 22

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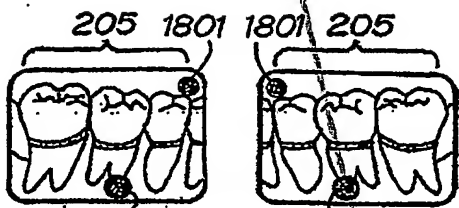


Fig. 22

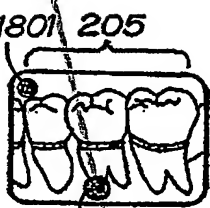


Fig. 23

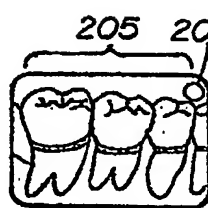


Fig. 24

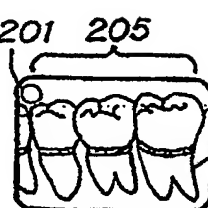


Fig. 25

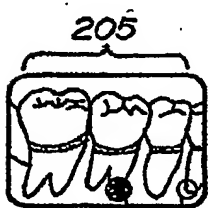


Fig. 26

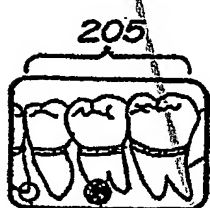


Fig. 27

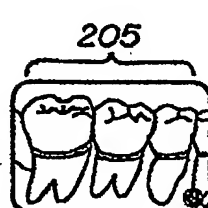


Fig. 28

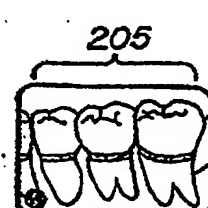


Fig. 29

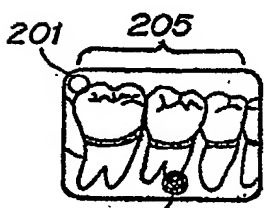


Fig. 30

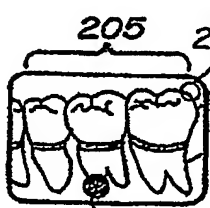


Fig. 31

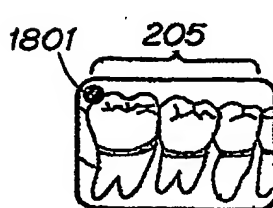


Fig. 32

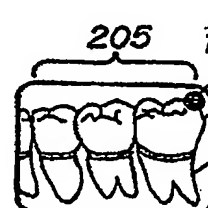


Fig. 33

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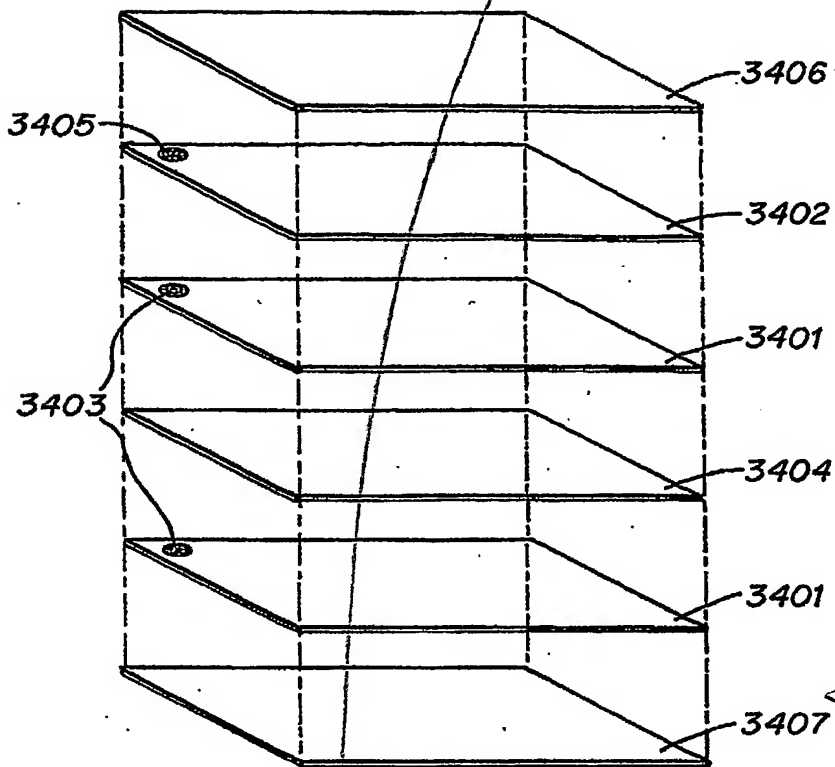


Fig. 34

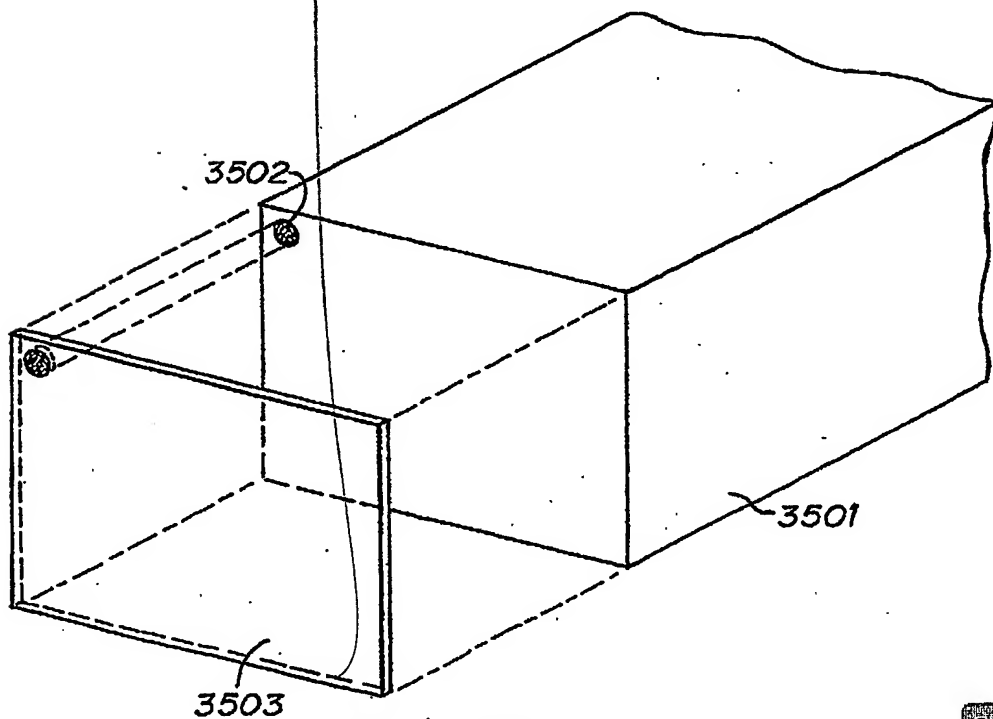


Fig. 35

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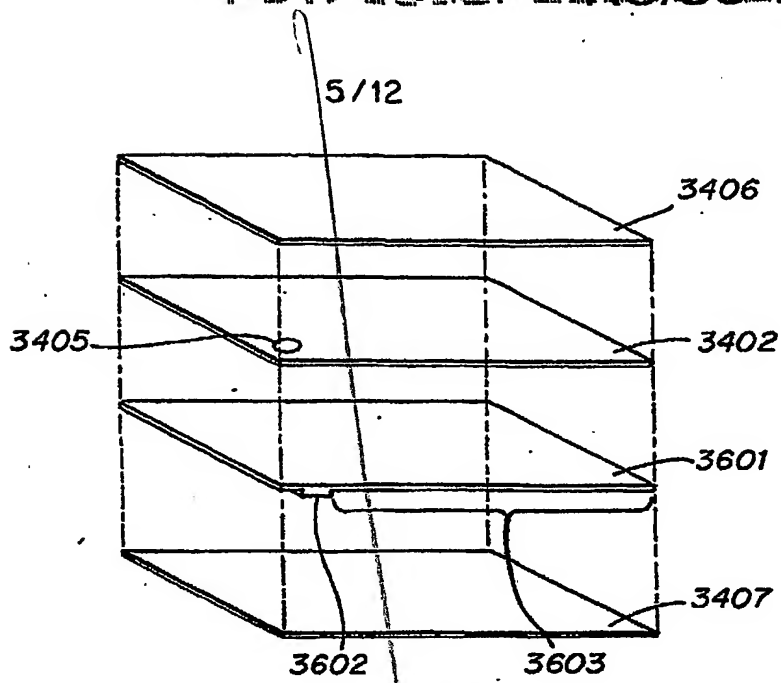


Fig. 36

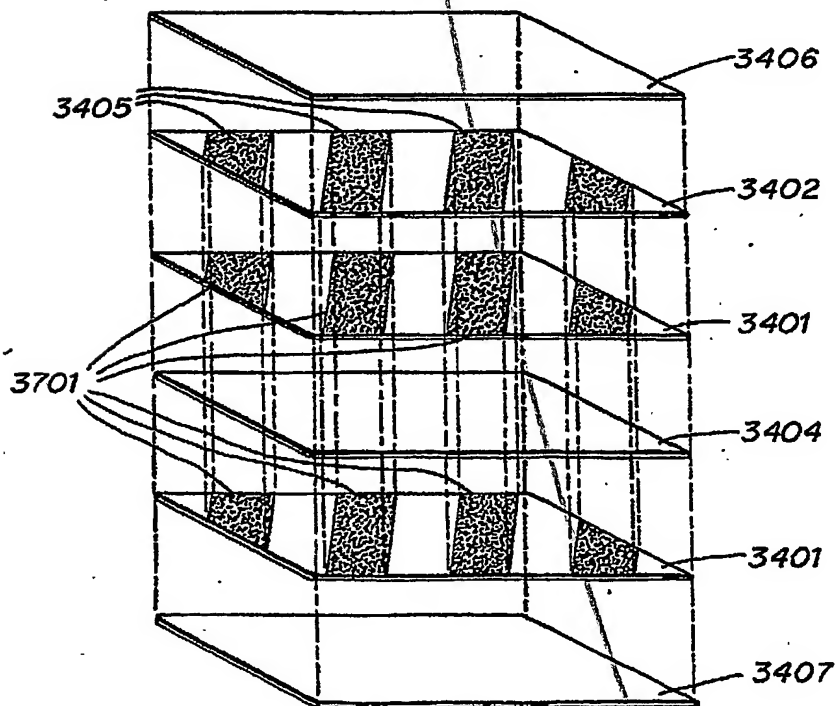


Fig. 37

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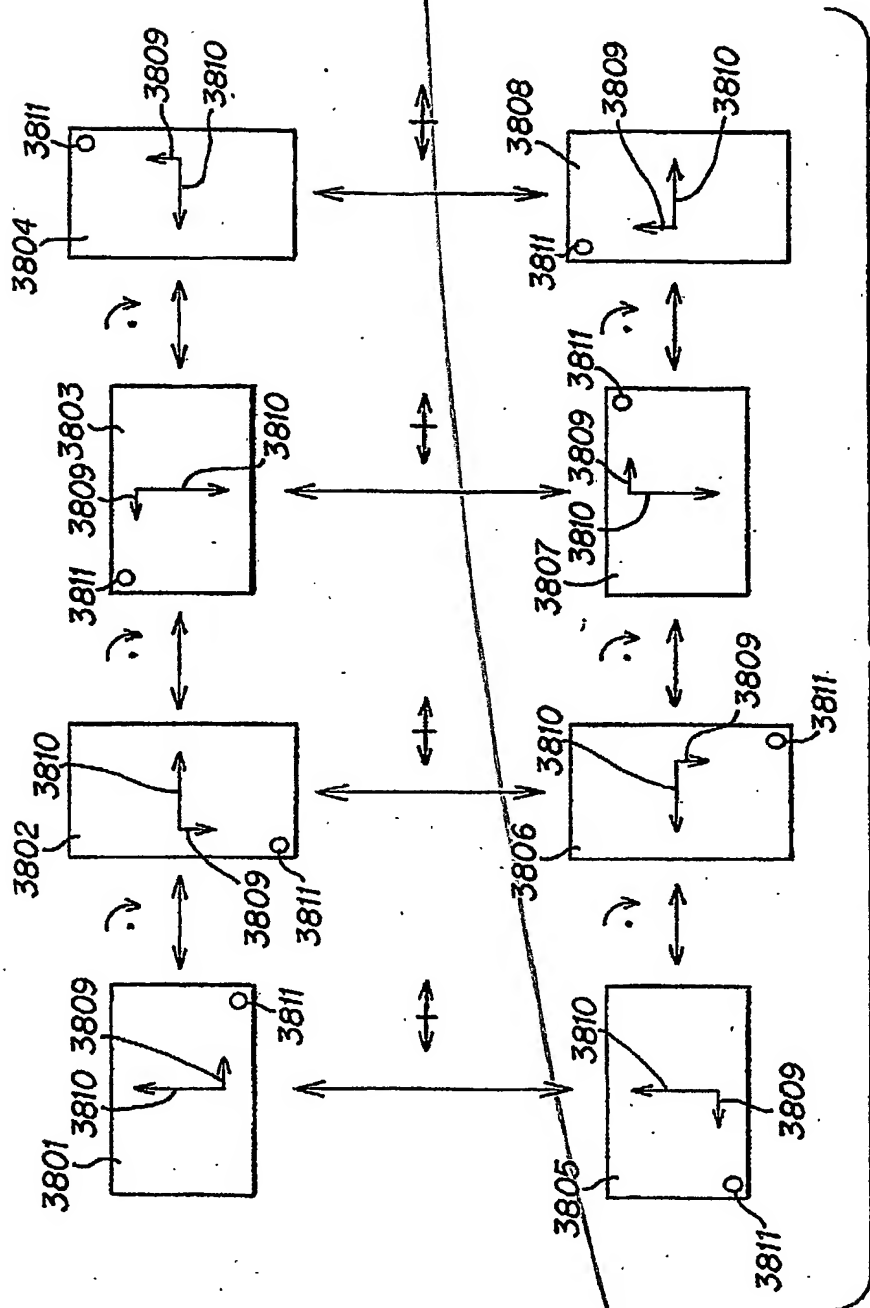


Fig. 38

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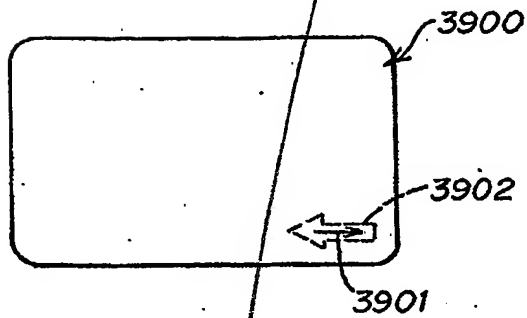


Fig. 39

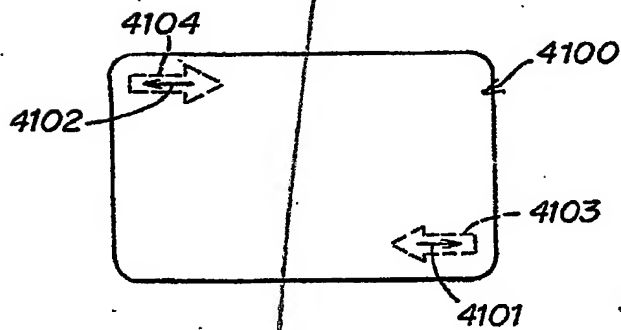


Fig. 41

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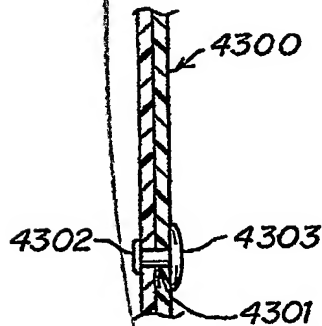


Fig. 43

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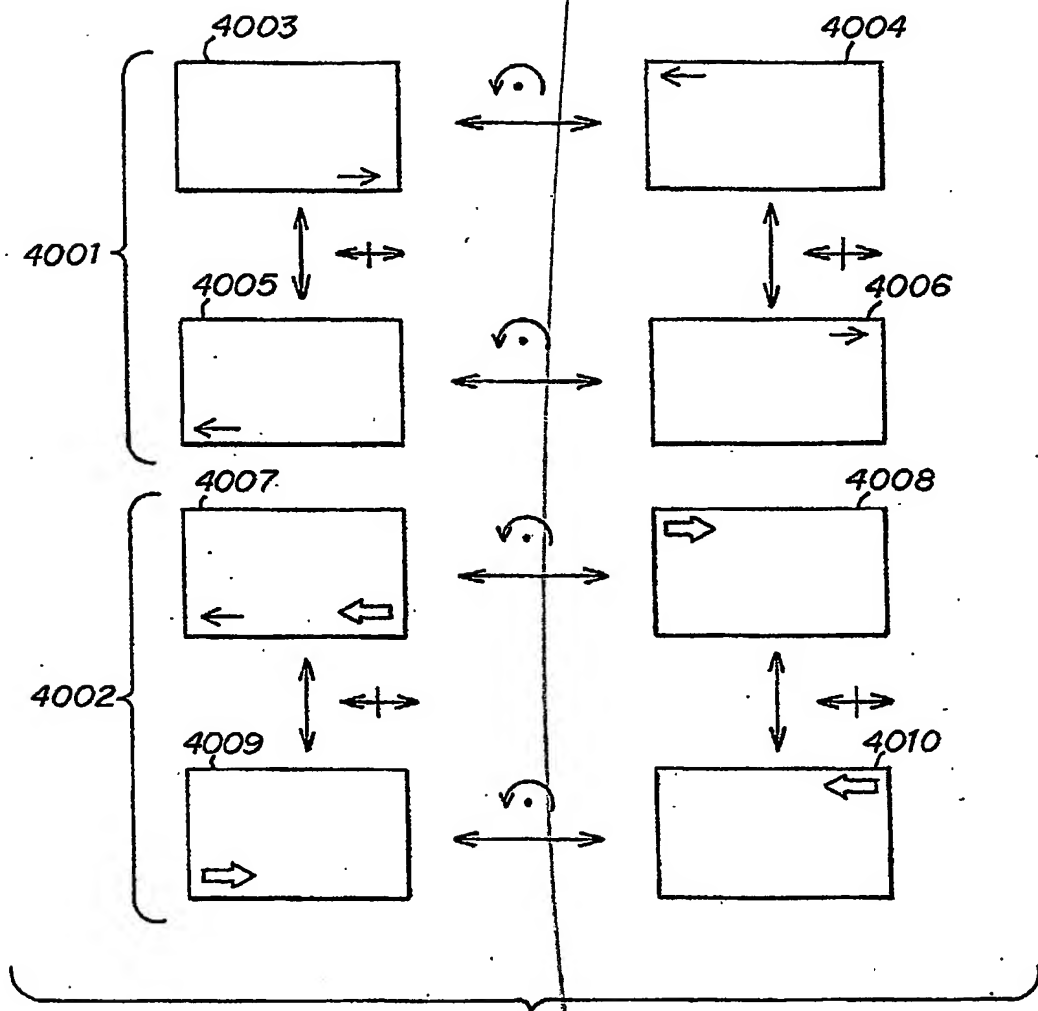


Fig. 40

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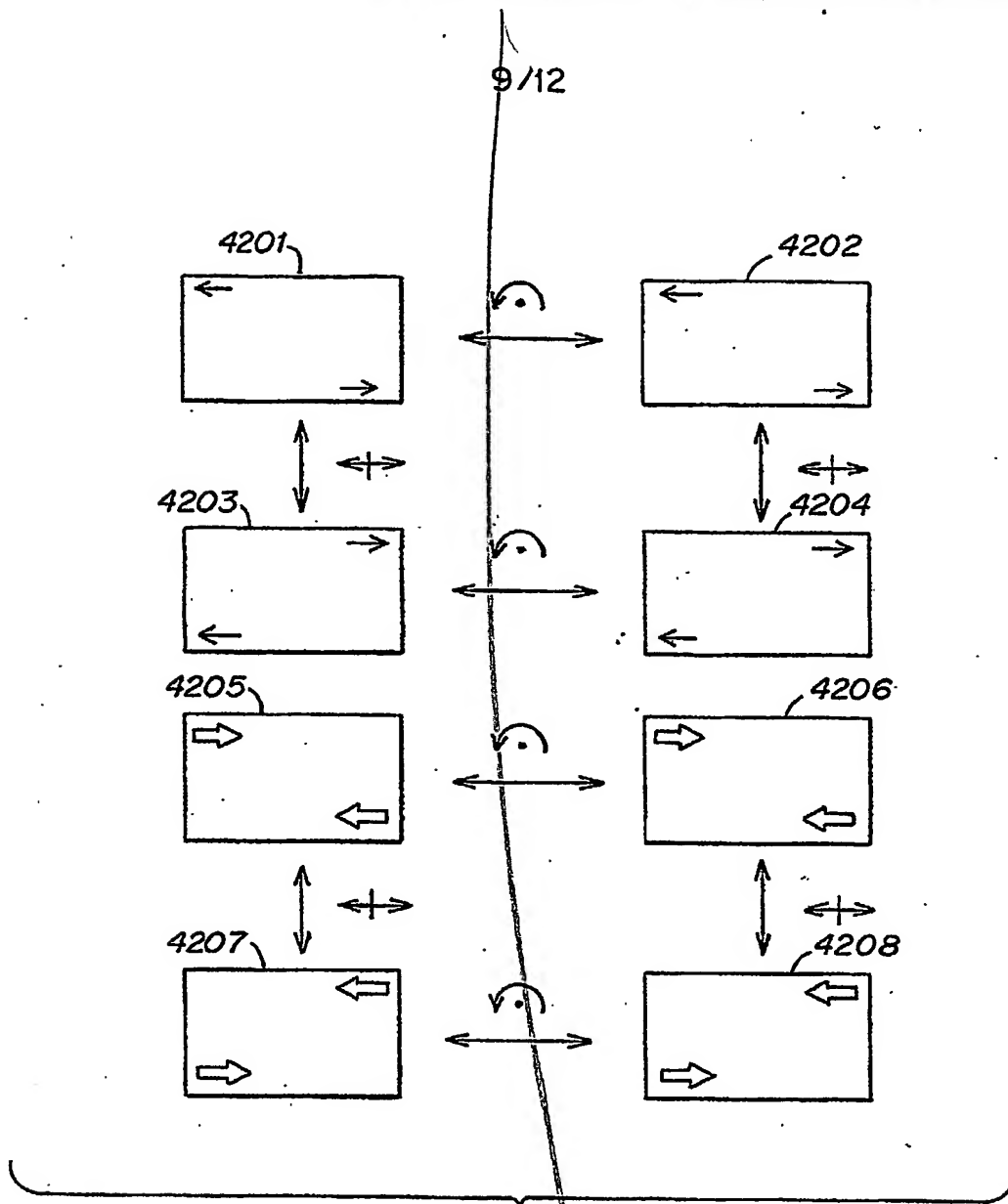


Fig. 42

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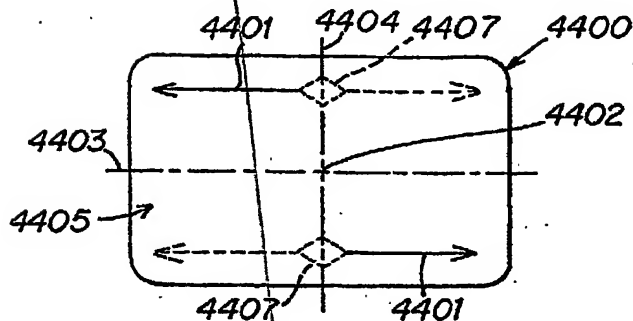


Fig. 44A

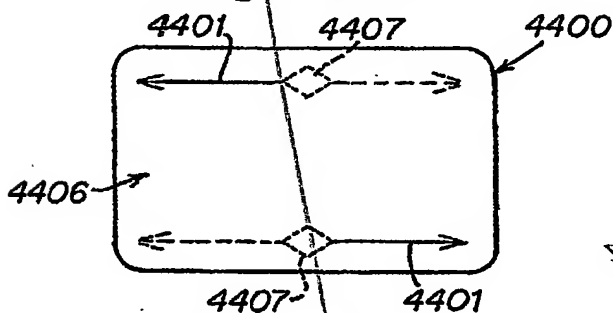


Fig. 44B

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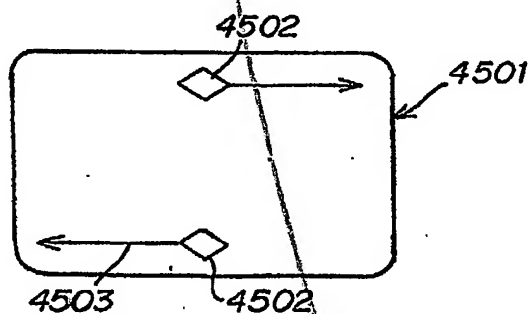
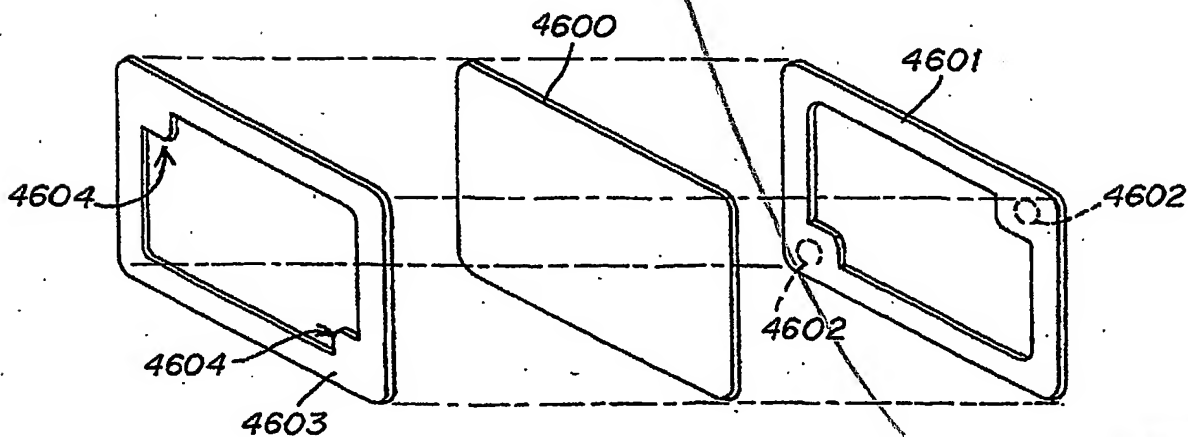


Fig. 45



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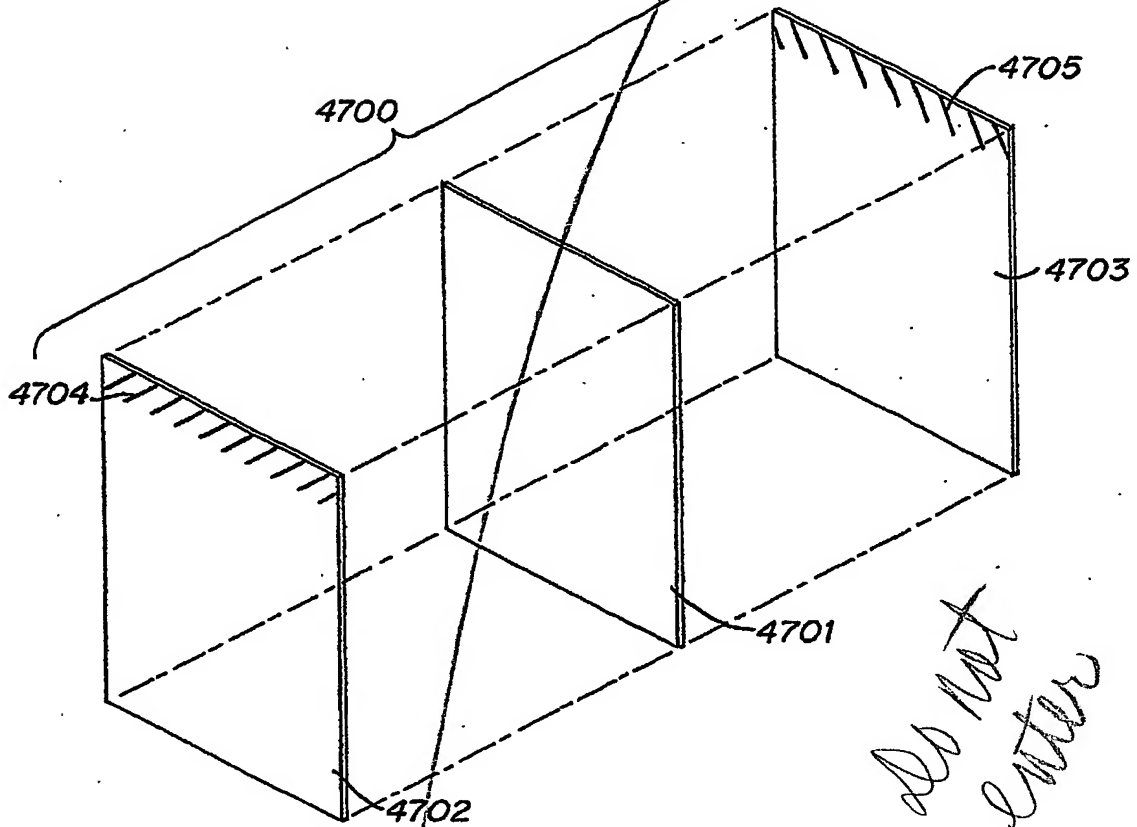


Fig. 47

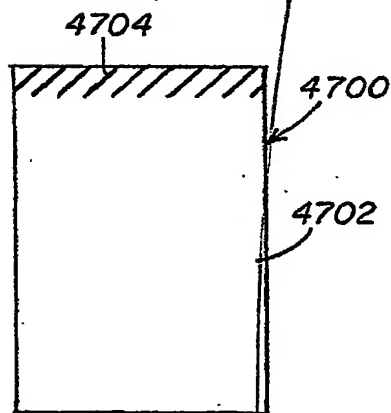


Fig. 48

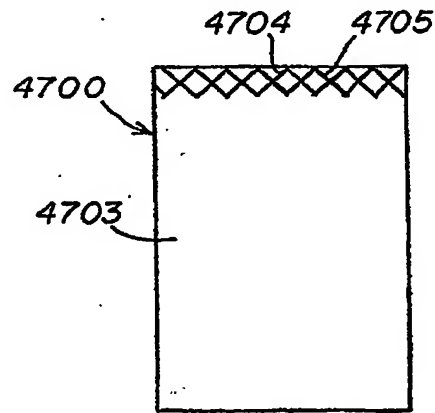


Fig. 49

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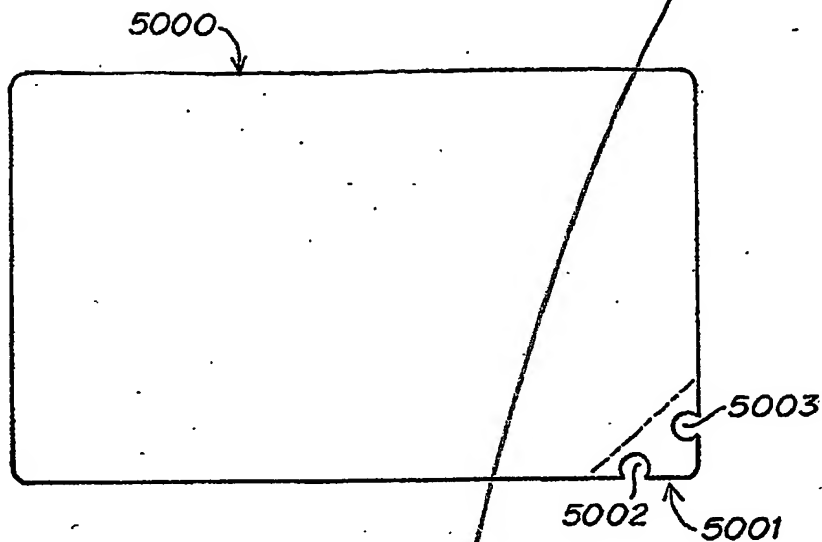


Fig. 50

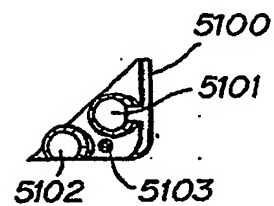


Fig. 51

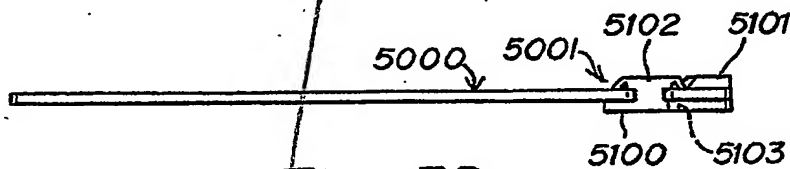


Fig. 52

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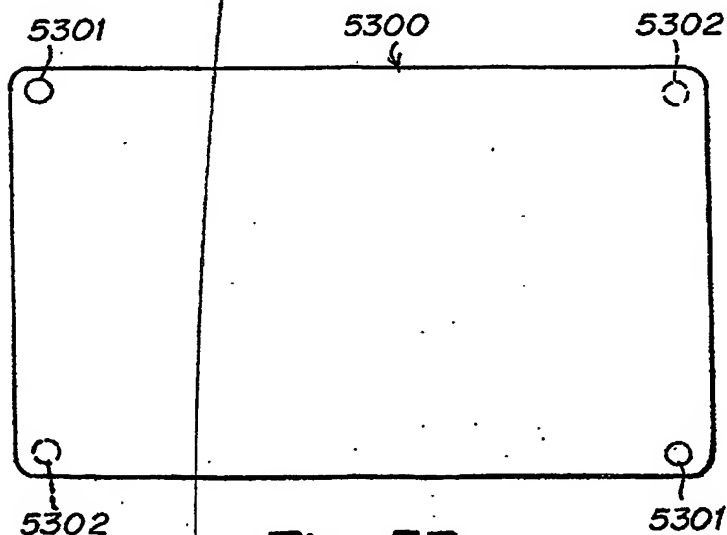


Fig. 53

10. The plate of claim 9, wherein the marker is a rivet having a head and a foot, the head and the foot covering different areas.

11. The plate of claim 9, wherein the marker comprises:

a front frame; and

a back frame;

the front frame and the back frame covering different areas.

12. The plate of claim 9, wherein the marker comprises:

a front-side pattern always present in the image; and

a back-side pattern present in the image in combination with the front-side pattern after exposure from the back side.

13. The plate of claim 9, wherein the marker comprises:

a corner element having a front and a back, the front and the back covering different areas not including a region of interest.

14. The plate of claim 9, having a layer sensitive to the radiation that is readable only from the front side, the back side marker further comprising at least one of a material that enhances reading the sensitive layer and a material that attenuates reading of the sensitive layer.

15. The plate of claim 9, wherein the back side marker further comprises at least one of a material that enhances exposure of the plate in a defined region and a material that attenuates exposure of the plate in the defined region.

16. The plate of claim 15, wherein the back side marker further comprises one of a heavy element, an alloy including a heavy element, a compound including a heavy element or a salt of a heavy element.

17. The plate of claim 16, the heavy element being one of Pb, Sn, Bi, I and Ba.

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18. The plate of claim 1, further comprising a front side marker producing a mark in the image whose appearance in the image on the plate indicates exposure from the front side.

19. The plate of claim 18, having a layer sensitive to the radiation that is readable at least from the front side, the front side marker further comprising at least one of a void defined in the layer sensitive to the radiation, a material that enhances a signal returned in the area of the marker when reading the sensitive layer and a material that attenuates the signal returned in the area of the marker when reading the sensitive layer.

20. The plate of claim 19, readable only from the front side by exciting the layer sensitive to the radiation with an excitation wavelength to generate a return signal at a return signal wavelength, the front side marker functionally opaque to at least one of the excitation signal wavelength and the return signal wavelength.

21. The plate of claim 19, wherein the front side marker further comprises one of a heavy element, an alloy including a heavy element, a compound including a heavy element or a salt of a heavy element.

22. The plate of claim 21, the heavy element being one of Pb, Sn, Bi, I and Ba.

23. The plate of claim 19, wherein the front side marker further comprises a void defined in the layer sensitive to the radiation.

24. The plate of claim 1, the marker having asymmetry about at least one axis and the marker further comprising a front side marker and a back side marker.

25. The plate of claim 24, wherein the marker has horizontal asymmetry about a vertical axis relative to a normal image orientation.

26. The plate of claim 25, wherein the front side marker further comprises: a region defined to have a directional marker shape pointed in a first direction when viewed from the front side.

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27. The plate of claim 26, wherein the back side marker further comprises:
a region defined to have a directional marker shape pointed in a second direction
different from the first direction when viewed from the front side.

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28. The plate of claim 27, wherein the back side marker is positioned so as to alter
the appearance in the image of the front side marker when the plate is exposed from the back
side and read from the front side.

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29. The plate of claim 24, wherein the marker has vertical asymmetry about a
vertical axis relative to a normal image orientation.

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30. The plate of claim 29, wherein the front side marker further comprises:
a region defined to have a directional marker shape pointed in a first direction when
viewed from the front side.

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31. The plate of claim 30, wherein the back side marker further comprises:
a region defined to have a directional marker shape pointed in a second direction
different from the first direction when viewed from the front side.

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32. The plate of claim 31, wherein the back side marker is positioned so as to
obscure the front side marker when the plate is exposed from the back side and read from the
front side.

33. The plate of claim 19, further comprising another sensitive layer, wherein the
back side marker is disposed between the sensitive layer and the other sensitive layer, and the
plate further comprising another front side marker relative to the other sensitive layer.

*do not
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